UNIVERSITY OF ESWATINI

MAIN EXAMINATION, FIRST SEMESTER

APRIL 2021

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER: Switchgear and Protection

COURSE CODE : EEE552

TIME ALLOWED: Three Hours

INSTRUCTIONS:

1. There are Five (5) questions in this paper. Answer any four(4) questions. Each question carries 25 marks.
2. If you think not enough data has been given in any question you may assume any reasonable values.

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER CONTAINS SEVEN (7) PAGES INCLUDING THIS PAGE

Question 1 (25 Marks)

(a) What are the consequences and protection of the following generator faults?

i. Prime mover failure. [5]

ii. Loss of excitation [5]

(b) Discuss the MVA method of fault level calculation and state its advantages [5]

(c) For the single line diagram shown in Fig. Q1(c), draw the equivalent MVA diagram and hence find the MVA value at the point of fault [10]

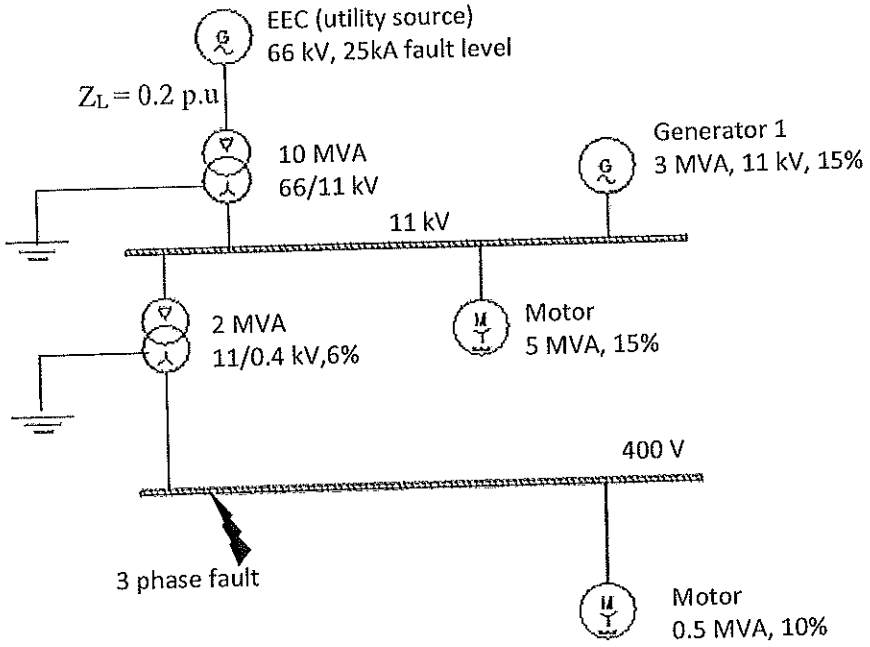

Fig. Q1(c)

Question 2 (25 Marks)

(a) Explain the arc phenomena for initiation of arc, maintenance of arc and the methods used for interrupting the arc. [5]

(b) Define the following terms

(i) Re-striking voltage [2]

(ii) Recovery voltage [2]

(iii) RRRV [2]

(c) A 50Hz, 3-phase alternator has a line voltage of 66 kV. The generator is connected to a circuit breaker; the inductive reactance up to the circuit breaker is 10 Ω/phase. The distributed capacitance up to the circuit breaker between phase and neutral is 0.05μF.

(i) Determine the peak re-striking voltage across the contacts of circuit breaker. [4]

(ii) Frequency of re-striking voltage transients [3]

(iii) Maximum RRRV [3]

(iv) Average rate of re-striking voltage up to peak re-striking voltage. [4]

Question 3 (25 Marks)

(a) ANSI/IEEE (IEEE Standard C37.2-2008) protective relays are generally referred to by standard device numbers. Letters are sometimes added to specify the application. Describe the devices denoted by the following device numbers. [5]

(i) 21
(ii) 27
(iii) 51
(iv) 67
(v) 87

(b) Discuss the difficulties in transformer differential protection and outline how to overcome them. [8]

(c) Consider the three-phase Δ –Y connected, 20-MVA, 11/0.4 kV transformer with differential relay protection as shown in the Fig. 3(c):

(i) Determine the CT ratios for differential protection of the three-phase, Δ–Y connected transformer, such that the circulating current in the transformer does not exceed 4 A. [10]

(ii) Compute the relay current setting for faults drawing up to 120 % of rated transformer current. [2]

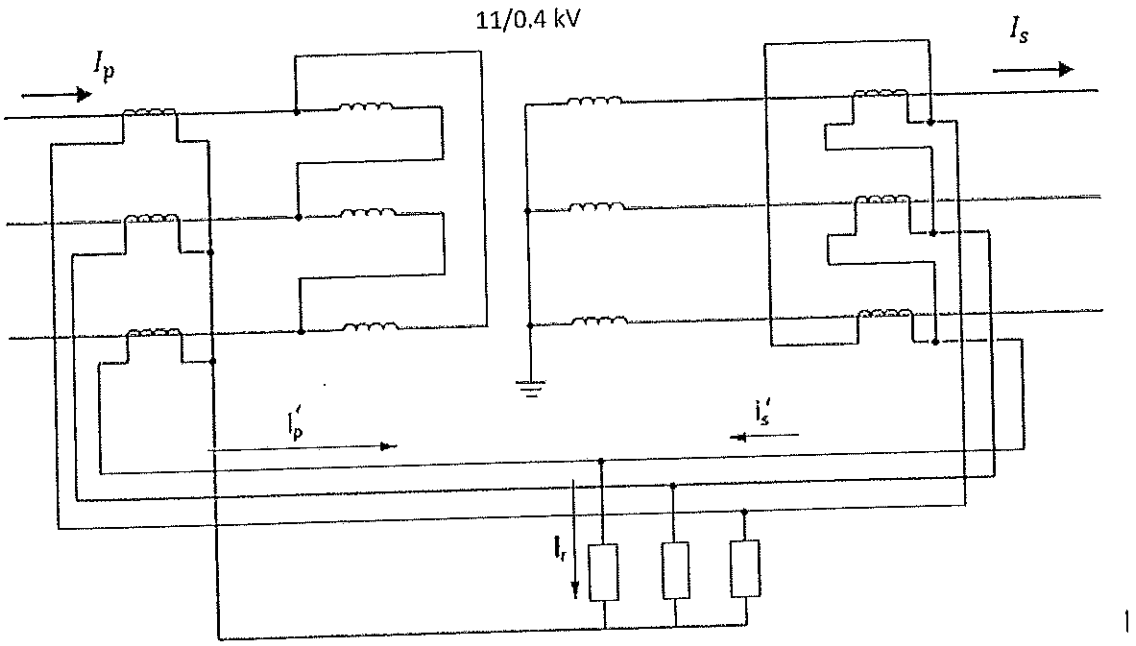

Fig. Q3(b)

Question 4 (25 Marks)

(a) Discuss the following terms with reference to power system protection:

(i) Earth wire shielding Angle [3]

(ii) Arcing ground [2]

(iii) Discuss the type of earthing illustrated in Fig. Q4(a) [3]

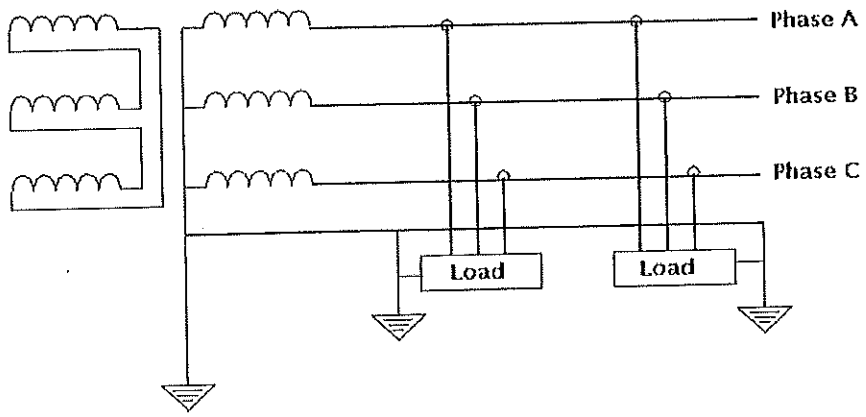

Fig. Q4(a)

(b) A 66 kV, 3-phase, 50 Hz, 300 km long transmission line consists of three conductors of effective diameter 30mm arranged vertically with 2.8 m spacing and regularly transposed. Find the inductance and kVA rating of the Peterson coil in the system.[7]

(c) The following table gives the positive sequence line impedances as well as the CT and VT ratios of the distance relay at B12 for 400 kV (line to line) systems.

Line	Positive sequence impedance Ω
1-2	7+j30
2-3	12+j20
2-4	15+j35
1-3	5+j21

Circuit Breaker	CT ratio	VT ratio
B12	2000:5	3000:1

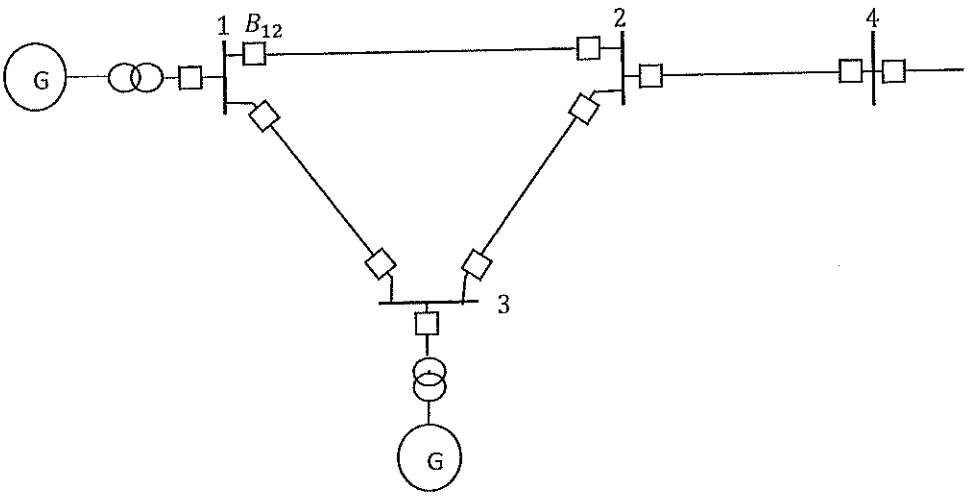

Fig. Q4(c)

(i) Determine the three impedance relay zones settings Z_{r1}, Z_{r2}, Z_{r3} for the breaker B_{12}. [10]

Question 5 (25 marks)

(a) Derive and draw the characteristics of an impedance relay. [5]

(b) Explain with sketches the R-X diagrams for the following distance relays.

(i) Mho relay [3]

(ii) Reactance relay [3]

(iii) Directional Relay [3]

(c) What is the need of relay coordination? [2]

(d) A current transformer with a current ratio of 500:5 is used for over current protection as shown in the figure below. Determine the relay operating time if an IDMT, IEC Standard inverse curve is used with plug setting of 120%, assume minimum time dial of 0.1s [9]

Useful Information

Curve Description	*Standard*	α	β	L
Moderately Inverse	*IEEE*	*0.02*	*0.0515*	*0.114*
Very Inverse	*IEEE*	*2.0*	*19.61*	*0.491*
Extremely Inverse	*IEEE*	*2.0*	*28.2*	*0.1217*
Inverse	*CO8*	*2.0*	*5.95*	*0.18*
Short Time Inverse	*CO2*	*0.02*	*0.0239*	*0.0169*
Standard Inverse	*IEC*	*0.02*	*0.14*	*0*
Very Inverse	*IEC*	*1.0*	*13.5*	*0*
Extremely Inverse	*IEC*	*2.0*	*80.0*	*0*
Long Time Inverse	*UK*	*1.0*	*120*	*0*